

# Heart Sound Screening in High, Low and Middle Income Communities

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■ *Heart sound screening was performed on elementary school children in three San Mateo County communities, using the Phonocardioscan, a portable analog-digital computer. Although these communities differed significantly in socio-economic backgrounds, the incidence of previously known and unknown heart disease was not dissimilar. However, there was an unusual difference in community reaction to the heart sound study, with the families in the middle class area exhibiting more anxiety than those in the high and low income communities.*

THE PHONOCARDIOSCAN\* has been used in a number of communities to detect heart disease in children and has produced valuable quantitative and qualitative information on the presence of heart defects.<sup>1-3</sup> In most of these studies, however, there has been no correlation of findings with the socio-economic background of the children or community reaction to such screening programs.

This is a report of my experience with the Phonocardioscan with pupils in the third and fourth grades in three elementary school districts in San Mateo County. The study embraced represents high, middle and low income groups in one of the wealthiest counties in the United States.

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## Procedure

The Phonocardioscan is a 20-pound transistorized analog-digital computer with heart sound circuitry engineered to detect systolic murmurs greater than Grade 1½ systolic (scale of 6); high and low frequency diastolic murmurs; and second heart sounds more widely split than 50 milliseconds. There is a single concomitant electrocardiographic timing lead obtained by placing two suction cup electrodes on the chest in the seventh interspace, mid-clavicular line, bilaterally.

By using a small velocity microphone placed consecutively at the apex and the fourth, third and second interspaces, left sternal edge, abnormal findings are conveyed to the technician by a series of flashing lights. These can be counted automatically by a special counter built into the system or, as in this study, counted by the technician and then recorded. There is no print-out by the computer. All sounds are recorded in mid-expiration.

Any child who caused the lights to flash consistently on the computer in any part of the cardiac cycle was re-screened by another technician on another day. Children who continued to show phonocardiogram abnormalities were then evaluated by me at their schools on still another day. Then, the children were examined in both sitting and recumbent positions, and the presence of any murmurs and of any unusually wide-splitting of the heart sounds or rhythm disturbances was noted. Femoral and radial pulses were also palpated. Maneuvers, such as the Valsalva, were used repeatedly to help differentiate between functional murmurs and those that seemed significant. Presumably from these observations a board-certified pediatric cardiologist could make a fairly educated clinical assessment. Nevertheless, since electrocardiograms and x-ray films were not made routinely on these patients, but only on those considered to have organic disease, it is possible that some organic murmurs were designated as functional. Undoubtedly, any errors should come to light eventually.

Brief questionnaires were sent to all parents of third and fourth graders who were examined in the three elementary school districts of the county. These solicited brief information—history of heart disease, rheumatic fever or heart murmurs—and requested permission to screen the child with the Phonocardiogram.

### The Communities (Table 1):

*San Mateo County* is immediately to the south of San Francisco and is a middle class residential county with strong agricultural ties. It has areas of extreme elegance and affluence, and others of relative poverty. Even in the low income sections of the county, most people have a one-family dwelling, an automobile, and the opportunity to send children to a well-equipped school. Relatively, however, there is a considerable gap between the rich and the poor districts of this county. The three communities studied were Hillsborough, Belmont and East Palo Alto.

*Hillsborough* lies 15 miles south of San Francisco, has no commercial endeavors, and remains a residential community with an average income among the top five in the United States. Its main product is children, who are extremely well cared for; there is an excellent elementary school system. The parents tend to be conservative but anxious for the best for their children. Even though every child in the school population had his own personal

physician (usually a pediatrician) and had been seen repeatedly through the years, the families were pleased to have the children evaluated by the computer (only two percent refused). There was little anxiety that the computer would discover any previously undetected heart disease.

*Belmont*, 24 miles south of San Francisco, and only five miles from Hillsborough, is a middle class community whose population has quadrupled since 1950. It has some commercial enterprises but, for the most part, it houses the commuters who use the Southern Pacific trains or the Bayshore Freeway into San Francisco each day.

The parents, like their counterparts in Hillsborough, want only the best for their children. They take an active part in Parent Teachers Association and other school activities, but in general they are more anxious about their children than the Hillsborough parents, and are particularly upset if they find that they differ in any way from the average. They exhibited more anxiety about the testing program, and a higher proportion (four percent) refused to have the computer used on their children. Some of those who refused did so with much vehemence, and even threatened to keep the children home from school the day the Phonocardiogram was used, to be sure they would not be studied. Local physicians received phone calls from parents asking whether or not they should permit the study to be done. This was not the case in Hillsborough, even though parents in both communities received almost identical information about the proposed study. I cannot explain this difference in reaction.

*East Palo Alto-Ravenswood*: This district draws its pupils primarily from East Palo Alto, a large neighborhood of 80 percent non-Caucasians, and of significantly lower income than the other two communities (Table 1). There are no pediatricians there, relatively few physicians of any kind, and many people visit local clinics instead of private physicians for their medical care. Because the children in this community do not have the continuity of care of children in Hillsborough and Belmont, I felt that a survey of the third and fourth grade students with the Phonocardiogram might be beneficial but made the mistake of approaching the district in the same manner as the other two communities, that is, "I wished to do a study." This was a serious error, as a "study" was not wanted. For some time, "doing a study" in East Palo Alto had become almost a way of life for researchers who periodically garnered Federal and other grants,

**TABLE 1.—San Mateo County Population Statistics\***

	Hillsborough	Belmont	East Palo Alto
Total population .....	8,650	25,100	25,650
Annual family income (average) .....	\$31,500	\$10,000	\$6,350
Family home value (average) .....	\$75,000	\$32,500	\$9,500
Percent of school population			
Caucasian .....	99.1	98	20
Non-Caucasian .....	.09	2	80

\*From San Mateo County Department of Vital Statistics.

came into the community, did their project, retired to create their theses, and never returned with the solutions to the problems they had encountered. The residents of East Palo Alto had put up with these studies with remarkably good grace but when nothing of significance was done to alleviate the problems this good-natured acceptance faded. By the time I presented my project, there was open hostility.

Helped by sympathetic persons who gave me some insight into the views of the community, I made an entirely different presentation that emphasized the positive aspects of the project—that is, to discover whose hearts needed attention so that care could be given. With this shift from “study” to “care,” opposition abated — only three percent of the parents refused to cooperate.

#### Results (Table 2):

**Hillsborough:** One child was found to have congenital heart disease by the Phonocardiogram, but was already known to have the condition (a small atrial septal defect). No previously undiagnosed cardiac lesions were discovered. Functional murmurs were found in only three percent of the children, although the true incidence of functional murmurs was probably higher. More than three percent of the children were picked up on the original screening with the Phonocardiogram; with re-screening, the number dropped to the three percent level. This is not unusual when one considers the variability of functional murmurs, particularly

their relation to physical or emotional stress. Many children who were obviously disturbed the first time they encountered the Phonocardiogram were noticeably less upset on re-screening. Admittedly, even with this explanation, the incidence of functional murmurs was quite low.

A group of eleven children (four percent of the total) who were reported by their parents to have either a heart murmur or heart disease, were consistently passed as normal by the Phonocardiogram. When these children were evaluated at school, I found only a Grade 1 systolic murmur without any evidence of organic disease. However, no electrocardiograms or x-ray films were made for evaluation beyond this clinical opinion. These children with the positive history but negative Phonocardiogram findings were, therefore, considered to have been “de-labelled” from the stigmata of heart disease. Several volunteer mothers (for the study) were visibly relieved to see the computer pass their children as normal when they had been thought to have a murmur of significance. Obviously, this process of “de-labelling” could be exaggerated and should be accepted with some reservations.

The study was well received, and follow-up questioning of parents, school administrators and physicians revealed no tension or anxiety had been created in parents or children.

**Belmont:** In decided contrast to those of Hillsborough and East Palo Alto, the children in Belmont showed a significant level of anxiety during the study. A number of children were reduced to

**TABLE 2.—Data on Phonocardiogram Screening in Third and Fourth Grades in San Mateo County**

	Hillsborough		Belmont		East Palo Alto	
	No.	%	No.	%	No.	%
Total number of students .....	275		676		1045	
Number refused Phonocardiogram .....	6	2	24	4	34	3
Phonocardiogram positive .....	10	3	59	9	89	9
Organic disease .....	1	0.4	6	0.9	11	1
Previously known .....	1	0.2	2	0.3	2	0.1
Previously unknown .....	0		4	0.6	9	0.9
Functional murmurs .....	9	3	29	4	72	7
No murmur detected, although						
Phonocardiogram positive twice .....	0		24	4	6	0.5
Phonocardiogram negative but history						
of heart disease or murmur (the						
“de-labelled” group) .....	11	4	15	2	16	1

tears; one child fainted. That this anxiety was not limited to the children was indicated by frantic calls from parents as to why their children required more than one screening. With few exceptions, the children all had personal physicians (generalists or pediatricians) who had examined them a number of times, yet they were surprisingly uneasy in the test situation.

The incidence of organic heart disease in these children is skewed somewhat by the fact that two of them had already had corrective operations on the heart. The other children with organic disease had previously undiagnosed defects (a small ventricular septal defect, likely of the muscular portion of the septum, and congenital aortic stenosis, probably of moderate severity).

Five percent of these children had functional murmurs, many of which seemed related more commonly to the outflow tract of the left ventricle (that is, near the aortic valve) than the outflow tract of the right ventricle. These murmurs were often of diamond-shaped, crescendo-decrescendo character, Grade I-II intensity maximal in the left fourth interspace, left sternal edge, but also well heard in the suprasternal notch. There was no thrill, no ejection click, no diastolic murmur nor any change with the Valsalva maneuver. Other functional murmurs were the usual vibratory type heard well at the second and third interspaces, left sternal edge, and unassociated with significant splitting of the second heart sound or with any diastolic murmur. These were readily changed by the Valsalva maneuver.

Fifteen children who were thought to have heart murmurs of significance were passed as normal ("de-labelled") by the Phonocardioscan.

*East Palo Alto:* My original thesis that there was probably more previously undetected heart disease in East Palo Alto than in Hillsborough proved correct, but by a rather slim margin. Nine children had such lesions as bicuspid aortic valve, aortic or pulmonic stenosis and small ventricular septal defects, none of which appeared to be of major hemodynamic significance. They will be evaluated further. It is unlikely that they will ever need surgical repair, but it is possible that chemoprophylaxis at the time of any operations in the mouth might be indicated to prevent subacute bacterial endocarditis. Seven percent of the children had functional murmurs discovered by the computer. As no examination of the blood was done, it is not possible

to say whether some of these might have been due to nutritional or sickle cell anemia.

In general, these children accepted the study with little apprehension, and the schools reported no parental anxiety.

A smaller proportion of children (1.6 percent) were de-labelled in East Palo Alto than in the other two communities.

One child, in whom abnormality was picked up by the computer, proved to have an unusual case of acute pericarditis. She was well and attending school without complaint when she was found by the Phonocardioscan to have abnormal sounds in both systole and diastole. My examination the following day confirmed the presence of a friction rub, and she was admitted to the hospital. (A brief resumé of her unusual hospital course is described in the Addendum.) It is obvious that the discovery of this acute cardiac illness by the computer was purely fortuitous and cannot be used by itself as justification for cardiac screening. It does illustrate, however, a random finding of a kind that can be expected in any large volume screening project.

## Discussion

Should heart sound screening be used routinely in elementary schools? It is certainly less expensive to use a computer to scan the children than to have pediatricians or cardiologists listen to hundreds of hearts or to tape-recordings of heart sounds. The San Mateo study averaged 85 cents per child. There is also the element of fatigue. Physical auscultation of many children cannot be done by one person for extended periods; whereas, the computer does not tire and remains reliable. Studies have shown that while the Phonocardioscan is not as accurate as a cardiologist, it can select cardiac lesions better than a general practitioner or general pediatrician.

Children with unknown cardiac lesions should be detected before they start the exceedingly vigorous physical training in school that is usually initiated at the fifth or sixth grade levels. In the affluent middle class districts, where children generally receive regular medical care, the likelihood of finding previously unknown cardiac defects is not great. For the occasional defect that is discovered, there remains the question of how much anxiety and tumult has been created by the mechanics of the study. Middle class parents, in particular, tend to be very apprehensive about their children if they vary from the norm. The attitude toward the

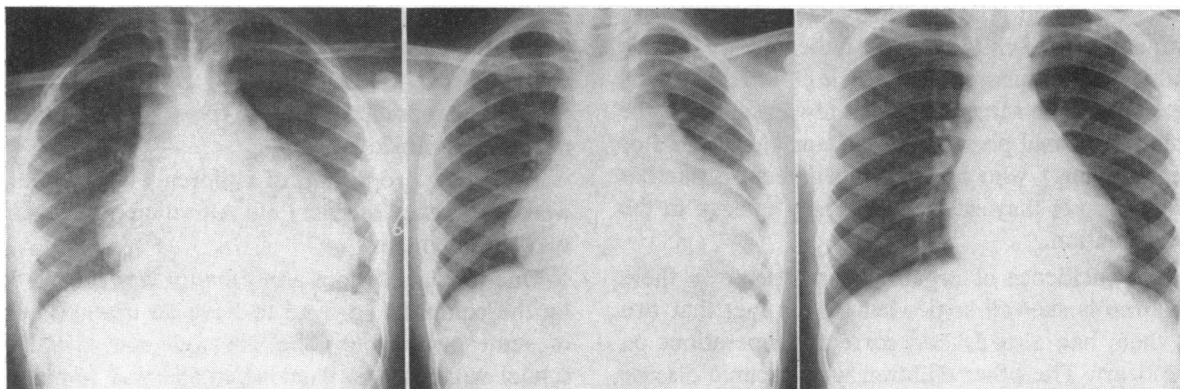


Figure 1.—X-ray films of chest taken on the first (left), third (center) and ninth (right) hospital days, showing evolution of the pericardial effusion.

computer evaluation of the heart was no exception; the ratio of worried parents in Belmont to the small number of previously unknown lesions detected is a distressing observation.

The generally good acceptance of this procedure by the less affluent community suggests that if a study is presented in the right way and the help which will result is emphasized, screening of children with the Phonocardioscan in such communities can be acceptable and prove of value.

It must be further emphasized that any study must be carried out by well trained technicians under close supervision of a cardiologist or cardiac-oriented pediatrician.

The advent of the Phonocardioscan represents an interesting beginning of the computer age in medicine. Any problems involved in its direct application to the living subject will certainly be overcome, and spectacular achievements can be expected to result in all medical fields. Particularly, the Phonocardioscan can be an important tool in detecting heart disease among children throughout the schools as well as in the various programs for poor people throughout the country.

#### *Addendum:*

The Phonocardioscan showed both systolic and diastolic murmurs in an asymptomatic 9-year-old girl. My examination revealed a friction rub and she was, therefore, admitted to the teaching service at San Mateo General Hospital. An x-ray film of the chest showed a large cardiac shadow consistent with pericardial effusion (Figure 1). Since the patient was still asymptomatic, no therapy was instituted; instead, she was carefully watched by the resident staff. She did well for 48 hours then became critically ill, with tamponade. X-ray films showed increased cardiomegaly. She was immediately given large doses of steroid intravenously, and within a short time improved clinically and radiographically. One can only speculate that the course of disease might have been less benign had she first arrived at the hospital when she was critically ill.

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